

UNCLASSIFIED

WOODWARD-CLYDE CONSULTANTS CHICAGO IL F/G 13/13  
NATIONAL DAM SAFETY PROGRAM, EATON DAM (MO 31163), MISSISSIPPI --ETC(U)  
APR 81 R G BENGREEN, L M KRAZYNSKI DACW43-M1-C-0038

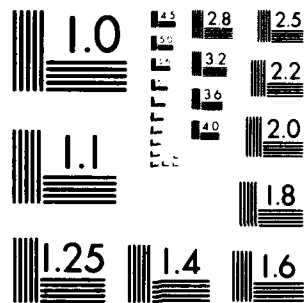
F/G 13/13

DACW43-41-C-0039

NL

1000

END  
DATE  
FILMED  
12-8  
DTIC



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A<sub>1</sub>

AD A107399

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A407	399
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Eaton Dam (MO 31163) St. Francois County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
7. AUTHOR(s) Woodward-Clyde Consultants		8. CONTRACT OR GRANT NUMBER(s) DACW43-81-C-0039
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE April 1981
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 6 National Dam Safety Program. Eaton Dam (MO 31163), Mississippi - Kaskaskia - St. Louis Basin, St. Francois County, Missouri. Phase I Inspection Report.		13. NUMBER OF PAGES Approximately 65
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES All DTIC reports will be in black and white		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

## INSTRUCTIONS FOR PREPARATION OF REPORT DOCUMENTATION PAGE

**RESPONSIBILITY.** The controlling DoD office will be responsible for completion of the Report Documentation Page, DD Form 1473, in all technical reports prepared by or for DoD organizations.

**CLASSIFICATION.** Since this Report Documentation Page, DD Form 1473, is used in preparing announcements, bibliographies, and data banks, it should be unclassified if possible. If a classification is required, identify the classified items on the page by the appropriate symbol.

### COMPLETION GUIDE

**General.** Make Blocks 1, 4, 5, 6, 7, 11, 13, 15, and 16 agree with the corresponding information on the report cover. Leave Blocks 2 and 3 blank.

**Block 1.** Report Number. Enter the unique alphanumeric report number shown on the cover.

**Block 2.** Government Accession No. Leave Blank. This space is for use by the Defense Documentation Center.

**Block 3.** Recipient's Catalog Number. Leave blank. This space is for the use of the report recipient to assist in future retrieval of the document.

**Block 4.** Title and Subtitle. Enter the title in all capital letters exactly as it appears on the publication. Titles should be unclassified whenever possible. Write out the English equivalent for Greek letters and mathematical symbols in the title (see "Abstracting Scientific and Technical Reports of Defense-sponsored RDT/E," AD-667 000). If the report has a subtitle, this subtitle should follow the main title, be separated by a comma or semicolon if appropriate, and be initially capitalized. If a publication has a title in a foreign language, translate the title into English and follow the English translation with the title in the original language. Make every effort to simplify the title before publication.

**Block 5.** Type of Report and Period Covered. Indicate here whether report is interim, final, etc., and, if applicable, inclusive dates of period covered, such as the life of a contract covered in a final contractor report.

**Block 6.** Performing Organization Report Number. Only numbers other than the official report number shown in Block 1, such as series numbers for in-house reports or a contractor/grantee number assigned by him, will be placed in this space. If no such numbers are used, leave this space blank.

**Block 7.** Author(s). Include corresponding information from the report cover. Give the name(s) of the author(s) in conventional order (for example, John R. Doe or, if author prefers, J. Robert Doe). In addition, list the affiliation of an author if it differs from that of the performing organization.

**Block 8.** Contract or Grant Number(s). For a contractor or grantee report, enter the complete contract or grant number(s) under which the work reported was accomplished. Leave blank in in-house reports.

**Block 9.** Performing Organization Name and Address. For in-house reports enter the name and address, including office symbol, of the performing activity. For contractor or grantee reports enter the name and address of the contractor or grantee who prepared the report and identify the appropriate corporate division, school, laboratory, etc., of the author. List city, state, and ZIP Code.

**Block 10.** Program Element, Project, Task Area, and Work Unit Numbers. Enter here the number code from the applicable Department of Defense form, such as the DD Form 1498, "Research and Technology Work Unit Summary" or the DD Form 1634, "Research and Development Planning Summary," which identifies the program element, project, task area, and work unit or equivalent under which the work was authorized.

**Block 11.** Controlling Office Name and Address. Enter the full, official name and address, including office symbol, of the controlling office. (Equates to funding/sponsoring agency. For definition see DoD Directive 5200.20, "Distribution Statements on Technical Documents.")

**Block 12.** Report Date. Enter here the day, month, and year or month and year as shown on the cover.

**Block 13.** Number of Pages. Enter the total number of pages.

**Block 14.** Monitoring Agency Name and Address (if different from Controlling Office). For use when the controlling or funding office does not directly administer a project, contract, or grant, but delegates the administrative responsibility to another organization.

**Blocks 15 & 15a.** Security Classification of the Report: Declassification/Downgrading Schedule of the Report. Enter in 15 the highest classification of the report. If appropriate, enter in 15a the declassification/downgrading schedule of the report, using the abbreviations for declassification/downgrading schedules listed in paragraph 4-207 of DoD 5200.1-R.

**Block 16.** Distribution Statement of the Report. Insert here the applicable distribution statement of the report from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

**Block 17.** Distribution Statement (of the abstract entered in Block 20, if different from the distribution statement of the report). Insert here the applicable distribution statement of the abstract from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

**Block 18.** Supplementary Notes. Enter information not included elsewhere but useful, such as: Prepared in cooperation with ... Translation of (or by) ... Presented at conference of ... To be published in ...

**Block 19.** Key Words. Select terms or short phrases that identify the principal subjects covered in the report, and are sufficiently specific and precise to be used as index entries for cataloging, conforming to standard terminology. The DoD "Thesaurus of Engineering and Scientific Terms" (TEST), AD-672 000, can be helpful.

**Block 20.** Abstract. The abstract should be a brief (not to exceed 200 words) factual summary of the most significant information contained in the report. If possible, the abstract of a classified report should be unclassified and the abstract to an unclassified report should consist of publicly-releasable information. If the report contains a significant bibliography or literature survey, mention it here. For information on preparing abstracts see "Abstracting Scientific and Technical Reports of Defense-Sponsored RDT&E," AD-667 000.



DEPARTMENT OF THE ARMY  
ST. LOUIS DISTRICT, CORPS OF ENGINEERS  
210 TUCKER BOULEVARD, NORTH  
ST. LOUIS, MISSOURI 63101

REPORT TO  
ATTENTION OF

SUBJECT: Eaton Dam Phase I Inspection Report (MO 31163)

This report presents the results of field inspection and evaluation of the Eaton Dam (31163).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam;
- b. Overtopping of the dam could result in failure of the dam; *and*
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED  
\_\_\_\_\_  
Chief, Engineering Division

4 JUN 1981  
\_\_\_\_\_  
Date

APPROVED BY:

SIGNED  
\_\_\_\_\_  
Colonel, CE, District Engineer

5 JUN 1981  
\_\_\_\_\_  
Date

Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
INAC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Classification	
Distribution/	
Availability Codes	
Avail and/or	
Dist	Special
A	

**EATON DAM**

St Francois County, Missouri  
Missouri Inventory No. 31163

**Phase I Inspection Report  
National Dam Safety Program**

Prepared by

**Woodward-Clyde Consultants**  
Chicago, Illinois

Under Direction of  
St Louis District, Corps of Engineers

For  
Governor of Missouri  
April 1981

## **PREFACE**

*This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.*

*In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.*

*It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.*



PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Eaton Dam
State Located	Missouri
County Located	St Francois
Stream	Eaton Branch
Date of Inspection	22 October 1980

Eaton Dam, Missouri Inventory Number 31163, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist). The dam was constructed to impound lead tailings.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, US Army, Washington, DC, with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification of those dams which may pose hazards to human life and property, based on available data and visual inspection of the dam. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential. The SLD estimated damage zone length extends approximately two miles downstream of the dam to the Big River flood plain. Within the first mile downstream are a lead tailings dam (Leadwood Tailings Dam, MO 30274), Missouri Highway 8, and at least four occupied dwellings.

Eaton Dam is classified intermediate size based on its storage capacity of approximately 5420 ac-ft, of which only 420 ac-ft is water storage. The dam height, from the toe to the minimum top of dam, is approximately 38 ft. The intermediate size dam classification includes dams between 40 and 100 ft in height, or having storage capacity between 1000 and 50,000 ac-ft.

The findings of the visual inspection indicate the dam is in generally fair condition. This is principally due to the low spillway capacity. No evidence of cracking, excessive erosion, sinkhole development, unstable slopes, or detrimental settlement was noted. The embankment materials are judged highly susceptible to erosion by flowing water. Seepage estimated at approximately 5 gal/min was noted at the toe of the embankment at the time of our inspection. The surface of the reservoir was dry at that time except for a small shallow pool near the spillway (Fig 3-A). Seepage and stability analyses comparable to the guidelines are not on record, which is considered a deficiency.

Hydraulic and hydrologic analyses indicate the rock berm at the left (west) end of the dam will be overtopped by storm events that produce greater than 18 percent of the Probable Maximum Flood (PMF). The "Recommended Guidelines for Safety Inspection of Dams" require that intermediate size dams pass 100 percent of the PMF. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway capacity is calculated to be approximately 1000 ft<sup>3</sup>/sec with the reservoir at the minimum top of dam elevation of 831.8 ft. The spillway will pass the 1 percent probability-of-occurrence flood (100-yr flood) without overtopping the embankment. The 1 percent probability-of-occurrence flood is that flood which has a 1 percent chance of occurring any one year, or occurs on the average of once every 100 years.

It is recommended the following studies be conducted under the guidance of an engineer experienced in the design, construction, and maintenance of tailings dams.

- a. Design and construct a spillway system capable of passing 100 percent of the PMF without overtopping the dam. The spillway should be protected from erosion. Design considerations should include the discharge capacity for Leadwood Tailings Dam downstream. Modifications to the storage and discharge capacity at Eaton Dam should be coordinated with modifications to Leadwood Tailings Dam so as not to exceed the storage and discharge capacity at Leadwood.
- b. Perform seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams." These analyses should be made for appropriate loading conditions, including earthquake loads, and made a matter of record.

- c. Evaluate the feasibility of a practical and reliable warning system to alert downstream residents and traffic in the event hazardous conditions develop at this dam during periods of flooding.

It is recommended that a program of periodic inspections and monitoring be initiated at this facility. This program should include but not be limited to the following items:

- a. Inspect of the embankment and spillway to identify evidence of instability or significant erosion following heavy precipitation events.
- b. Monitor seepage at the toe of the dam to identify changes in the volume of flow or turbidity in the seepage water. Specifically, these observations should be made during periods of high water elevations in the reservoir.

It is recommended the owner take action on the remedial measures concerning the design of the spillway system without undue delay. The remaining recommendations should be acted on as soon as practical.

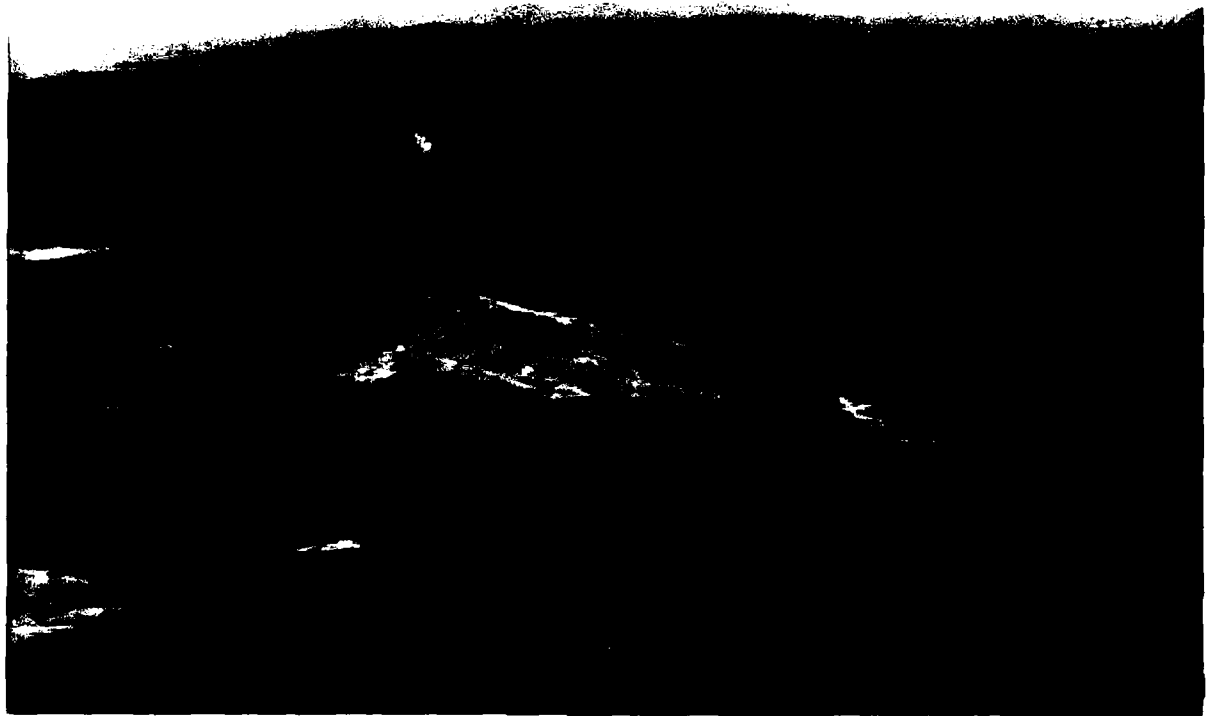
WOODWARD-CLYDE CONSULTANTS



Richard G. Berggreen  
Registered Geologist, No. 3572, CA



Leonard M. Krazynski, PE, No. C-14953, CA  
Vice President



**OVERVIEW  
EATON DAM**

**MISSOURI INVENTORY NUMBER 31163**

v

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
EATON DAM, MISSOURI INVENTORY NO. 31163  
TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	2
1.3	Pertinent Data	5
SECTION 2 - ENGINEERING DATA		
2.1	Design	9
2.2	Construction	9
2.3	Operation	9
2.4	Evaluation	10
2.5	Project Geology	10
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	12
3.2	Evaluation	14
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	15
4.2	Maintenance of Dam	15
4.3	Maintenance of Operating Facilities	15
4.4	Description of Any Warning System in Effect	15
4.5	Evaluation	15
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	16
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	19

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
----------------------	--------------	-----------------

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1	Dam Assessment	21
7.2	Remedial Measures	22

REFERENCES	24
------------	----

## FIGURES

1.	Site Location Map
2.	Drainage Basin and Site Topography
3-A.	Plan and Profile of Dam
3-B.	Dam, Spillway, and Discharge Channel Cross Sections
4.	Regional Geologic Map

## APPENDICES

A	Figure A-1: Photo Location Sketch
---	-----------------------------------

### Photographs

1. View along centerline of Eaton Dam, looking east. Note very flat cross sectional profile, tailings pile at far (east) end of dam, and eroded tailings dam and pond to the right of the tailings pile. Also note rock berm and small pool at near (west) end of dam. Spillway is at near end of rock berm.
2. Crest of dam planted with grass for erosion control. Tailings pile in distance at east end of dam. Looking east along crest.
3. Rock berm at west end of dam. Road along crest of berm. Impoundment is on the other side of berm. Looking southwest.
4. Seepage area at toe of Eaton Dam. Leadwood Tailings Dam and reservoir in the distance. Seepage estimated at approximately 5 gal/min. Looking north.
5. Spillway notch at west end of dam. Unpaved road crosses spillway in foreground. Looking north (downstream). Note bedrock exposed on far side of road in floor of spillway and downstream channel.
6. View of tailings area from crest of dam. Note lack of standing water and generally unvegetated tailings surface. Looking south (upstream) from crest of dam.
7. Small pond of standing water at upstream end of spillway. Spillway is at extreme right side of photo. Looking west.
8. Remnants of eroded tailings dam and pond. Gray unbedded material at right is former dam; light gray bedded material to the left is impounded tailings. View from top of tailings pile shown in Photos 1 and 2. Looking south.

Photographs (continued)

9. Discharge channel below spillway. Channel is eroded to bedrock. Spillway is in the distance. Looking south (upstream).
10. Waterfall eroded in spillway discharge channel. Note some solutioning has occurred along joints. Also note interbedded dolomite (top of falls) and shale (base of falls). Looking south (upstream).

B Hydraulic/Hydrologic Data and Analyses

**PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
EATON DAM, MISSOURI INVENTORY NO. 31163**

**SECTION I  
PROJECT INFORMATION**

**1.1 General**

- a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Eaton Dam, Missouri Inventory Number 31163.
- b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures, and conclude if additional studies, investigations, and analyses are necessary and warranted" (Chapter 3, "Recommended Guideline for Safety Inspection of Dams").
- c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams"; and Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams" prepared by the Office of the Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District, Corps of Engineers. These guidelines were developed with the help of several federal and state agencies, professional engineering organizations, and private engineers.



## 1.2 Description of Project

- a. Description of dam and appurtenances. Eaton Dam is an abandoned lead tailings dam. Although its construction and usage are typical of other lead tailings dams in the area, it is atypical of dams constructed for the impoundment of water. The unique nature of these lead tailings dams has a significant impact on their evaluation. A brief description of their construction and usage is necessary to distinguish the differences between these dams and conventional water-retaining dams.

The lead tailings dams in southeastern Missouri have been constructed over a long period of time and include dams ranging from very old abandoned dams constructed in the 1800's to new dams still under construction. Although the construction techniques have changed, these dams have many similarities.

At the beginning of a mining operation a starter dam is frequently constructed of waste rock and residual soil. This dam is used to impound surface runoff and mine water pumped from the underground workings. The water is used in the ore processing and the transport of tailings waste. The reservoir formed by the starter dam constitutes the initial tailings disposal area.

The tailings are the waste material produced by the beneficiation and processing of the lead ore to form a high-grade lead concentrate. The tailings are pumped in the form of a slurry from the processing plant to the disposal area. The coarse tailings fraction (medium to fine sand) is used to continue the construction of the dam embankment on top of the starter dam; the fine fraction (silt and fine sand) is deposited in the reservoir area. Separation of the coarse and fine fractions usually is done at a cyclone separator or a series of cyclones on the crest of the dam. The underflow or coarse fraction is deposited on the dam and the overflow or fine fraction is pumped into the reservoir where it settles.

The dams are typically constructed using the downstream method. That is, as the coarse tailings are added to the dam, they are deposited on the crest and downstream face. As a result, the centerline of the dam crest migrates downstream as the dam is raised.

Frequently the dam has a drainage system built into the foundation to aid in lowering the phreatic surface (water table) within the embankment. Water enters the dam both at the crest from the cyclone-deposited tailings and from the upstream face where the dam is in contact with the reservoir. A clay blanket may be constructed on the upstream face to reduce this infiltration from the reservoir.

A decant or water disposal system is typically constructed beneath the dam. This decant system consists of a vertical tower or sloping structure within the reservoir which decants or draws water from near the surface of the reservoir where the water contains the least sediment. This water is then carried beneath the dam through a large diameter pipe and exits downstream of the toe of the dam. From there it may be recycled or released to the natural stream drainage. The intake level of the decant tower or structure is regulated as the tailings and reservoir level rises to maintain a balanced system of inflow and outflow. The decant system also serves as overflow discharge in the event of heavy precipitation. This is generally additional to other spillway provisions.

Two characteristics are noteworthy regarding the typical silt and sand tailings used in the construction of these dams. First, the very uniform and small grain size as well as lack of clay or other binder makes this material extremely susceptible to erosion by flowing water. It is unlikely this material could survive significant overtopping without dam failure. If such a dam were to be overtopped, the silty-sandy material composing the embankment would likely erode in a V-shaped breach through which the storm water and the water stored behind the dam would flow. A portion of the tailings impounded behind the embankment would be eroded and carried by flowing water through the V-shaped breach.

Second, the finely ground limestone and dolomite are almost barren of nutrients necessary to support vegetation. It is frequently necessary to import topsoil or fertilizer in order to successfully vegetate the dam embankment. This difficulty in vegetating the surface of the dam contributes to the potential for erosion of the dam.

Eaton Dam varies somewhat from the standard plan for lead tailings dams. It was built upstream from an existing lead tailings dam and its foundation consists of the tailings impounded behind that dam (Leadwood, MO 30274). The cross section for the dam is very flat, on the order of 10(H) to 1(V) (Overview Photo and Photo 1, also Fig 3-B). The surface of the embankment is covered with topsoil and a fairly complete cover of grass has been planted and is reasonably well established. No decant system was built for this dam. Overflow passes through the spillway into the Leadwood reservoir and is discharged through either the decant system or spillway for the Leadwood Tailings Dam. No drainage system or seepage blanket was built for Eaton Dam. Eaton Dam has been abandoned since the mid 1950's. There are no facilities requiring operation at this dam.

- b. **Location.** Eaton Dam is located in the valley between the towns of Leadwood and Frankclay in St Francois County, on Eaton Branch, about  $\frac{1}{2}$  mile south of Missouri Highway 8 (Fig 1). The dam is in Sections 4 and 5, T36N, R4E, on the USGS Flat River, Missouri 7.5 minute quadrangle map (1958).
- c. **Size classification.** The dam is classified intermediate size based on its storage capacity of approximately 5420 ac-ft, of which only about 420 ac-ft is water storage. The dam height from the toe of the downstream slope to the minimum top of dam is approximately 38 ft. Under the definitions in the "Recommended Guidelines for Safety Inspection of Dams," an intermediate size dam is between 40 and 100 ft in height, or has between 1000 and 50,000 ac-ft of storage capacity.
- d. **Hazard classification.** The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends two miles downstream of the dam to the Big River flood plain. Within the first mile are Leadwood Tailings Dam (MO 30274), Missouri Highway 8, and at least four occupied dwellings. The contents of the estimated damage zone were verified by aerial reconnaissance. The potential for property damage and loss of life could be high in the event of dam failure.

- e. Ownership. We understand the dam is owned by St Joe Lead Co, PO Box 500, Viburnum, Missouri, 65566. Correspondence should be sent to the attention of Mr Jack Krokroskia.
- f. Purpose of dam. The dam was constructed to impound tailings produced in the milling and processing of lead ore mined in the vicinity. The dam has been inactive since the mid 1950's.
- g. Design and construction history. Information on the design and construction of Eaton Dam was obtained from interviews with Mr John Kennedy of St Joe Lead Co. Mr Kennedy was not present during past tailings disposal operations at the Eaton Dam.

Operations at Eaton Dam began in the early 1930's, shortly after operations were discontinued at the Leadwood Dam, immediately downstream. Construction of the dam and deposition of tailings continued until the mid 1950's.

The dam was built by distributing tailings from a line of slotted pipe supported above the crest of the dam. As the level of the tailings rose, the slotted pipe was periodically raised to avoid burying the pipe. The relatively flat slopes on the dam embankment reflect the depositional slope of the saturated material flowing out of the pipe.

The foundation of this dam was described as resting on tailings deposits previously impounded by the Leadwood Tailings Dam. Fine-grained tailings were pumped into the impoundment above the dam where they settled. The water impounded by Eaton Dam either seeps through the embankment or passes through the spillway into the reservoir for the Leadwood Tailings Dam downstream.

Following completion of the dam, a mantle of topsoil was spread over the tailings embankment and planted with grass to control surface erosion.

- h. Normal operational procedures. The dam is currently abandoned and there are no operating facilities at this site.

### 1.3 Pertinent Data

a. Drainage area.

2.70 mi<sup>2</sup>

b. Discharge at dam site.

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A (not applicable)
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	1000 ft <sup>3</sup> /sec
Total spillway capacity at maximum pool elevation	1000 ft <sup>3</sup> /sec

c. Elevations (ft above MSL).

Top of dam	831.8 to 859.9
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	Unknown
Toe of dam at maximum section	794.0

d. Reservoir.

Length of maximum pool	9250 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. Storage (acre-feet).

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	420, water 5000, tailings

f. Reservoir surface (acres).

Top of dam	163*
Maximum pool	163*
Flood control pool	N/A
Recreation pool	N/A
Spillway crest	5*

\*Tailings surface slopes downstream, restricting water storage to area immediately upstream of dam.

g. Dam.

Type	Lead tailings, deposited from slotted pipe
Length	2450 ft (2160 ft, tailings dam, 290 ft, rock berm)
Height	66 ft (maximum section) 38 ft (to minimum top of dam)
Top width	100 to 150 ft (tailings dam), 20 ft (rock berm)
Side slopes	Upstream 15 or 20 (H) to 1(V) on exposed section. Downstream 8 or 10 (H) to 1 (V)
Zoning	None. Homogeneous tailings.
Impervious core	None
Cutoff	None
Grout curtain	None

h. Diversion and regulating tunnel.

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. Spillway.

Type	Unlined, uncontrolled, broad tri-angular shape. Eroded to bedrock.
Length of weir	120 ft
Crest elevation	827.3 ft
Gates	None
Downstream channel	Unlined, eroded to bedrock, several small waterfalls and bedrock pinnacles contributing to energy dissipation.

j. Regulating outlets.

None

## SECTION 2 ENGINEERING DATA

### 2.1 Design

No design drawings or records were found for this dam. Mr John Kennedy, of St Joe Lead Co, supplied the information on the construction history of the dam. Mr Kennedy was not personally present during construction and active operation of the dam.

### 2.2 Construction

Construction dates on this dam are not known with much certainty. Construction was reported to have begun in the early 1930's, shortly after the operations at the Leadwood Tailings Dam were discontinued. Use of Eaton Dam for tailings disposal continued until the mid-1950's.

The dam is reported to be built on a foundation of tailings impounded behind the Leadwood Tailings Dam. The embankment was built up by discharge of tailings from a slotted pipe which extended the length of the present tailings embankment. As the tailings level rose, the pipe was also periodically raised to avoid burial. Fine tailings were discharged into the reservoir upstream of the dam. Overflow water and seepage through the dam flowed into the reservoir for Leadwood Tailings Dam downstream, and was discharged through the decant facility or through the spillway.

No other records were available on the construction of this dam.

### 2.3 Operation

Eaton Dam is abandoned at present and there are no operating records available. Water level in the reservoir is controlled by the ungated spillway at the left (west) end of the dam. No records were available on the history of flow through the spillway.



## 2.4 Evaluation

- a. Availability. The available information on engineering and construction is limited to interviews with Mr Kennedy of St Joe Lead Co. No records or design drawings were available.
- b. Adequacy. The available information is insufficient to evaluate the design of Eaton Dam.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency that should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by a professional engineer experienced in the design and construction of tailings dams.

- c. Validity. There is no reason to question the validity of the information obtained from Mr Kennedy. It agreed with the observations made during the inspection. However, the information is incomplete.

## 2.5 Project Geology

The dam site is located just north of the center of the Ozark structural dome. Regional dip of the bedrock is toward the north but there is much local variation in dip around buried and exposed Precambrian highlands.

The bedrock exposed in the vicinity of the dam is a flaggy to shaley dolomite. The area is mapped on the Geologic Map of Missouri (1979) as Cambrian age Elvins Group and Bonneterre Formation. The Elvins Group, consisting of the Davis Formation and Derby-Doerun Formation, is exposed at the surface and contains shale, siltstone, fine-grained sandstone, dolomite, and limestone conglomerate. The Bonneterre Formation, which occurs below the Elvins Group, is the host formation for the lead mineralization in this part of Missouri. The Bonneterre Formation is typically a gray, medium- to fine-grained dolomite, but mineralized zones may contain abundant granite and felsite debris eroded from the Precambrian basement complex.

The soil at the dam site is a slightly plastic, red-brown, gravelly to silty clay (CL). This soil is typical of the residual soils developed by the weathering of the carbonate bedrock in the area. The soil is mapped on the General Soils Map of Missouri (1979) as Peridge-Cantwell-Gasconade Soil Association.

The dam site is located near the north end of the Simms Mountain Fault System. The site is actually within this system which is about 5 mi wide and 40 mi long, in a northwest-southeast direction. Faults within the fault system typically show displacement up on the southwest side.

The faults in the immediate vicinity of the dam site are the Schultz Fault, about 1.5 miles northeast of the dam, the Mitchell Fault, about 1 mile east of the dam, and the Irondale Fault, about 1 mile south of the dam. These faults are within the Paleozoic bedrock and are likely Paleozoic in age. This fault, like others in the Ozark region, is not considered seismically active and the faults are not considered to pose an unusual hazard to the dam.

The dam is located about 100 mi north of the line of epicenters for the very large New Madrid Earthquakes, which occurred in 1811 and 1812. A recurrence of an earthquake of the magnitude of the New Madrid event could cause significant damage at the dam, but a study of this aspect of risk was beyond the scope of this Phase I inspection.

### SECTION 3 VISUAL INSPECTION

#### 3.1 Findings

- a. General. Eaton Dam was inspected on 22 October 1980. Mr John Kennedy of St Joe Lead Co accompanied the inspection team throughout the inspection. The results of the inspection indicate the embankment is in generally good condition.
- b. Dam. Eaton Dam is a lead tailings dam located immediately upstream of the reservoir for Leadwood Tailings Dam (MO 30274). Outflow from Eaton Dam flows into the reservoir area for Leadwood Tailings Dam. Both dams were constructed for tailings disposal from the St Joe Lead Leadwood mill.

Eaton Dam consists of ground dolomite lead tailings, primarily fine to medium sand. Construction of the dam is described in Section 2.2. The dam consists of two parts (Photo 1): the main embankment, a broad flat ridge composed of tailings, and a relatively short low berm of mine rock and soil (Fig 3-A and Fig A-1). The tailings portion is vegetated with grass planted for erosion control (Photo 2). The rock portion is nearly barren of vegetation and has an unpaved road along the crest (Photo 3).

No excessive settlement, slumping, cracking, or development of sinkholes was noted during the inspection. The vertical and horizontal alignment of the dam crest appeared undisturbed. No animal burrows were noted. No detrimental erosion was noted on the dam.

No record or evidence of overtopping of the dam was found during the visual inspection. The rock and soil berm is the lowest portion of the dam, and would thus be the first location to be overtopped. This berm appears to be able to withstand limited overtopping without failure (that is, for a relatively small depth and short time duration). The material comprising this berm is also judged to be resistant to wave erosion. The tailings portion of the embankment appears very susceptible to erosion and would likely be severely eroded in the event of overtopping.

At the time of our inspection, seepage was noted in a broad area, 40 to 50 ft in length at the toe of the tailings embankment (Photo 4). Rate of the seepage was estimated at approximately 5 gal/min. The seepage did not appear to be transporting any soil or tailings. The tailings surface upstream of the dam was dry, except for a small pool near the spillway. The seepage area is located at a considerable distance from the ponded water. The presence of a natural hill protruding through the tailings below the dam suggests this seepage could be occurring at the contact with the underlying natural ground.

- c. **Appurtenant structures.** The spillway at this dam is a broad triangular notch (Photo 5) at the left end of the dam (as the observer faces downstream). This notch appears to be in a natural stream channel. The spillway is unlined but is eroded to bedrock and little or no erosional deepening of the spillway is expected during flood flows. The unpaved road which runs along the crest of the rock berm crosses the spillway. No flow was occurring through the spillway at the time of the visual inspection. Small trees and brush are present along the banks of the spillway, but they are not expected to obstruct the spillway during flooding events.

No other appurtenant structures were identified at this dam.

- d. **Reservoir area.** The reservoir area for Eaton Dam is nearly filled with fine sand and silt tailings (Photo 6). Standing water was limited to a small pool (approximately one acre) near the spillway (Photo 7) at the time of the visual inspection.

At the right (east) end of the dam is a large tailings pile with slopes of approximately 2(H) to 1(V) (Photos 1 and 2). Some minor slumping may occur along these slopes. The remnants of an eroded tailings dam also form a portion of the right side of the reservoir (Photos 1 and 8). This tailings pile and tailings dam have been severely eroded and likely supply sediment to the reservoir area. The remainder of the slopes surrounding the reservoir are generally quite flat, 5(H) to 1(V) or less, are either wooded or developed with scattered residences, and are not anticipated to supply significant amounts of sediment to the reservoir.

No evidence of unstable slopes was noted surrounding the reservoir, with the exception of the tailings pile at the end of the dam.

- e. Downstream channel. The downstream channel flows from the spillway at the left end of the dam into the reservoir for Leadwood Tailings Dam, immediately downstream. The channel is eroded to bedrock (Photo 9) and several small, 2 to 5 ft high, waterfalls have been eroded in the channel (Photo 10). Some areas of steep soil banks occur along the channel, and are likely to be subject to erosion during flooding. Small trees and brush are also present in the channel, but do not appear sufficient to obstruct flow during flooding.

### 3.2 Evaluation

The visual inspection found the embankment to be in generally good condition; however, the overtopping analysis, Section 5, indicates the rock and soil berm will be overtopped by a flood greater than 18 percent of the Probable Maximum Flood. As a result, the facility is judged to be in fair condition. The tailings portion of the embankment is considered severely erodible in the event of overtopping. The rock and soil berm which forms the left end of the dam is considered moderately resistant to erosion.

The very broad flat slope of the main embankment indicates slope stability is not likely to be a cause for concern at this dam. Surface runoff erosion appears to be sufficiently controlled by the grass planted on the tailings dam.

Seepage was noted at the toe of the dam, but was not transporting any material and did not appear to pose a hazard to the stability of the dam. This seepage should be re-examined when the reservoir water is at a higher elevation.

The spillway does not appear subject to erosional deepening as it is eroded to bedrock. The spillway is not expected to be obstructed during flood flows.

Unstable and eroding slopes in the reservoir area appear limited to the tailings pile and eroded tailings dam at the right end of the Eaton Dam embankment. These areas are anticipated to supply sediment to the reservoir, but this will have little impact on the already nearly filled reservoir area.

## SECTION 4 OPERATIONAL PROCEDURES

### 4.1 Procedures

No operating procedures currently exist at this facility as the dam is abandoned.

### 4.2 Maintenance of Dam

No maintenance of the dam appears to be performed or planned.

### 4.3 Maintenance of Operating Facilities

There are no facilities requiring mechanical operation at this dam.

### 4.4 Description of Any Warning System in Effect

The visual inspection did not identify any warning system in effect at this dam.

### 4.5 Evaluation

There is no formal plan for periodic inspections nor performance of maintenance. This is considered a deficiency.

The feasibility of a practical warning system should be evaluated to alert downstream residents and traffic should potentially hazardous conditions develop at the dam during periods of heavy precipitation.

## SECTION 5 HYDRAULIC/HYDROLOGIC

### 5.1 Evaluation of Features

- a. Design data. No hydrologic or hydraulic design data were available for evaluation of this dam or reservoir; however, dimensions of the dam were surveyed on 13 November 1980, by James F. McCaul, III and Associates, Consulting Engineers/Land Surveyors, Potosi, Missouri. The data is presented in Figs. 3-A and 3-B. Other relevant data were measured during the visual inspection or estimated from topographic mapping. The map used in the analysis was the USGS Flat River, Missouri, 7.5 minute quadrangle map (1958).
- b. Experience data. No recorded rainfall, runoff, discharge, or pool stage historical data were found for this reservoir.
- c. Visual observations.
  1. Watershed. The watershed is mostly natural woods with some open brushland as well as two small towns, Frankclay and Wortham (Fig. 2). The area of the reservoir at the spillway crest elevation is approximately 6 percent of the total drainage area of 2.70 mi<sup>2</sup>. The total tailings reservoir is considerably larger than this, but the surface of the tailings slopes toward the dam and restricts water storage to a relatively small area immediately upstream from the dam (see Fig. 2).
  2. Reservoir. The reservoir and dam are best described by the maps and photographs enclosed herewith. The purpose of this impoundment was containment of tailings from lead mining and milling operations.
  3. Spillway. The spillway is at the northwest end of a rock berm which constitutes an extension of the tailings embankment. This spillway rests on bedrock, is ungated, and is approximately triangular in shape. The slope of the discharge channel downstream of the spillway indicates that the spillway may not act as the control section for flow.

4. Seepage. The magnitude of seepage through this dam is small and not hydrologically significant to the overtopping potential.

- d. Overtopping potential. One of the primary considerations in the evaluation of Eaton Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the rock berm or the tailings portion of the embankment. Since the spillway of this dam rests on bedrock, erosion in the spillway area due to high velocity discharge is not expected to be significant. For this evaluation the lowest portion of the rock berm, which is adjacent to the spillway, was considered to be the top of dam (elevation 831.8) for the purpose of determining the overtopping potential.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence and Probable Maximum Floods (PMF) were all based on initial water surface elevations equal to the spillway crest elevation. The results of the analyses indicate that a flood of greater than 18 percent of the PMF will effectively overtop the dam. The "Recommended Guidelines for Safety Inspection of Dams" requires intermediate size dams to pass 100 percent of the PMF. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The analyses also indicate that the spillway will pass the 1 percent probability-of-occurrence flood (100-yr flood) without overtopping the dam. The spillway capacity at the pool elevation where the dam is considered overtopped is approximately 1000 ft<sup>3</sup>/sec.

The following table presents the expected severity of overtopping for various precipitation events, assuming no erosion of the dam or spillway.

Precipitation Event	Maximum Reservoir Elevation, ft	Maximum Depth Over Dam, ft	Maximum Outflow, ft <sup>3</sup> /sec	Duration of Overtopping, hrs
1% Probability	831.7	0.0	970	0.0
18% PMF	831.7	0.0	990	0.0
50% PMF	834.3	2.5	4620	7.8
100% PMF	836.0	4.2	10720	10.8



It should be noted that at the PMF the depth of overtopping may reach over 4 ft and the low portion of the rock berm will be overtopped for nearly 11 hours. Velocity over the embankment at such depth may reach over 9 ft/sec and result in significant erosion of the rock berm. Also, during the PMF event some erosion would likely take place in the lowest portions of the tailings embankment which are located below elevation 836.0. Since the main body of the tailings embankment is generally above elevation 850 or higher, it appears that erosional failure in the main body of the embankment would not be likely at the surface. However, seepage and stability analyses should be performed to assess the stability of the tailings embankment under high reservoir level. Also the spillway and rock berm configuration should be re-examined in a more thorough study. The objective of this study should be a design and construction of a spillway system which would permit passage of the PMF through the reservoir without overtopping and with minimal erosion of the embankment.

Input data and output summaries for the hydrologic and hydraulic analyses are presented in Appendix B.

## SECTION 6

### STRUCTURAL STABILITY

#### 6.1 Evaluation of Structural Stability

- a. Visual observations. The visual inspection did not identify any evidence of structural instability at this dam. The very flat slopes, ranging from 8(H) to 1(V) on the downstream face to nearly 20(H) to 1(V) on the upstream face, indicate that slope instability is not likely to be a significant hazard to this dam.

Accounts of the construction history report that the dam was built on a foundation of tailings impounded by the Leadwood Tailings Dam downstream. Some settlement due to loading from the dam construction would be normally expected, but this likely occurred in the past and is not anticipated to significantly impact the facility in the future.

Seepage noted at the toe of the dam may be moving along the contact with natural ground, through the earlier tailings deposit or through the dam embankment. This seepage should be monitored to identify any transporting of soil or tailings which could occur at higher reservoir levels than that observed at the time of our visual inspection.

- b. Design and construction data. Information on the design and construction of Eaton Dam was obtained through interviews with Mr John Kennedy of St Joe Lead Co. No design drawings or records of construction were available for the visual inspection. Construction procedures are presented in Sections 1.2 and 2.2.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not on record. This is considered a deficiency which should be rectified.

- c. Operating records. The dam is inactive at present and has been inactive since the mid 1950's. No records were available of water levels, available storage, or flows through the spillway.
- d. Post construction changes. The lack of design drawings or construction records precludes identification of post construction changes at this facility. However, no obvious changes were apparent during the visual inspection.
- e. Seismic stability. The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated.

The uniform sand and silt size tailings are likely quite susceptible to liquefaction since a substantial portion of the tailings is likely to be saturated. While no accurate information is available on the phreatic surface within the tailings, the seepage at the toe of the dam with a very low reservoir surface suggests that substantial deformation and possibly failure of the embankment could occur during a severe seismic event.

## SECTION 7 ASSESSMENT/REMEDIAL MEASURES

### 7.1 Dam Assessment

- a. Safety. Based on the visual inspection and hydraulic/hydrologic analyses, Eaton Dam is judged to be in generally fair condition. This judgement is based on the small spillway capacity. The spillway is capable of passing 18 percent of the PMF without overtopping the dam, which is considered a deficiency. The "Recommended Guidelines for Safety Inspection of Dams" require intermediate size dams to pass 100 percent of the PMF as the spillway design flood. Overtopping could cause sufficient erosion to breach the rock berm which forms the low point on the dam crest.

Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" are not available, which is considered a deficiency.

- b. Adequacy of information. The visual inspection provided a reasonable base of information for the conclusions and recommendations presented in this Phase I report.

The lack of design documents such as static and seismic stability analyses and a seepage analysis for the dam as recommended in the guidelines precludes an evaluation of the static or seismic stability of the dam.

- c. Urgency. The deficiencies described in this report could affect the safety of the dam. Remedial measures concerning the spillway design should be initiated without undue delay.
- d. Necessity for Phase II. In accordance with the "Recommended Guidelines for Safety Inspection of Dams," the subject investigation is a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which

should be performed without undue delay are described in Section 7.2b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

## 7.2 Remedial Measures

- a. Alternatives. There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these general options are:
  1. Remove the dam, or breach it to prevent storage of water;
  2. Increase the height of dam and/or spillway size to pass the Probable Maximum Flood without overtopping the dam;
  3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy;
  4. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes the chances for loss of life).
- b. Recommendations. Based on our inspection of Eaton Dam, it is recommended that further study be conducted to evaluate, as a minimum, the following items.
  1. Design and construct a spillway system capable of passing 100 percent of the PMF without overtopping the dam. The spillway system should be protected from erosion. Design considerations should include the discharge capacity for Leadwood Tailings Dam downstream. Modifications to the storage and discharge capacity at Eaton Dam should be coordinated with modifications to Leadwood Tailings Dam so as not to exceed the storage and discharge capacity at Leadwood.
  2. Perform seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams." These analyses should be made for appropriate loading conditions, including earthquake loads, and made a matter of record.

3. Evaluate the feasibility of a practical and reliable warning system to alert downstream residents and traffic in the event hazardous conditions develop at this dam during periods of flooding.

All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of tailings dams.

Measures concerning the design of the dam spillway should be performed without undue delay. The remaining recommendations should be acted on as soon as practical.

c. O & M procedures. To provide adequate maintenance of this facility it is recommended that a program of periodic inspections be implemented as soon as practical. This program should include the following items.

1. Inspect the embankment to identify evidence of instability or significant erosion following heavy precipitation events.

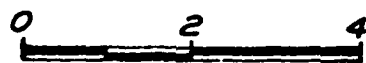
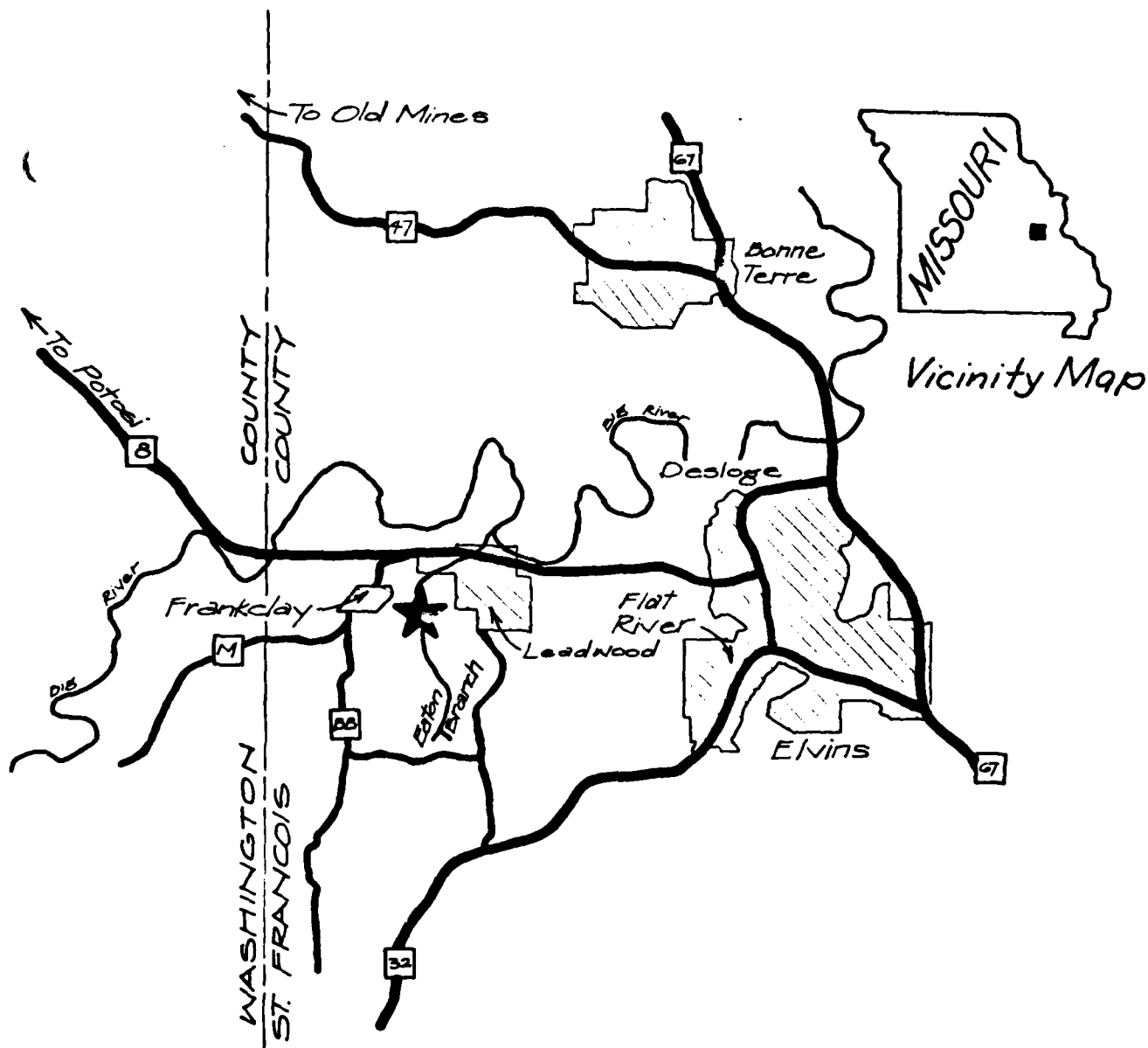
2. Monitor seepage at the toe of the dam to identify changes in the volume of flow or turbidity in the seepage water. Specifically, these observations should be made during periods of high water elevations in the reservoir.

3. Identify and perform any required maintenance to the embankment or spillway.

The inspection and any resulting maintenance should be performed under the guidance of an engineer experienced in the design and construction of tailings dams. Records of the inspection and maintenance performed should be kept.

## REFERENCES

- Allgood, F. P., and Persinger, I. D., 1979, Missouri General Soil Map and Soil Association Descriptions: US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.
- Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188: National Program of Inspection of Non-Federal Dams.
- Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106: National Program of Inspection of Non-Federal Dams.
- Hydrologic Engineering Center, US Army Corps of Engineers, 1978, Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations.
- McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, scale 1:500,000.
- Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, scale 1:500,000.
- St Louis District, US Army Corps of Engineers, 1979, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams.
- US Department of Agriculture, Soil Conservation Service, 1971, Hydrology: National Engineering Handbook, Section 4.
- US Department of Commerce, US Weather Bureau, 1956, Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours: Hydrometeorological Report No. 33.



Scale, miles

### Legend

- County Line
- State highway and Route No.
- River or Creek
- City or Town
- Project location



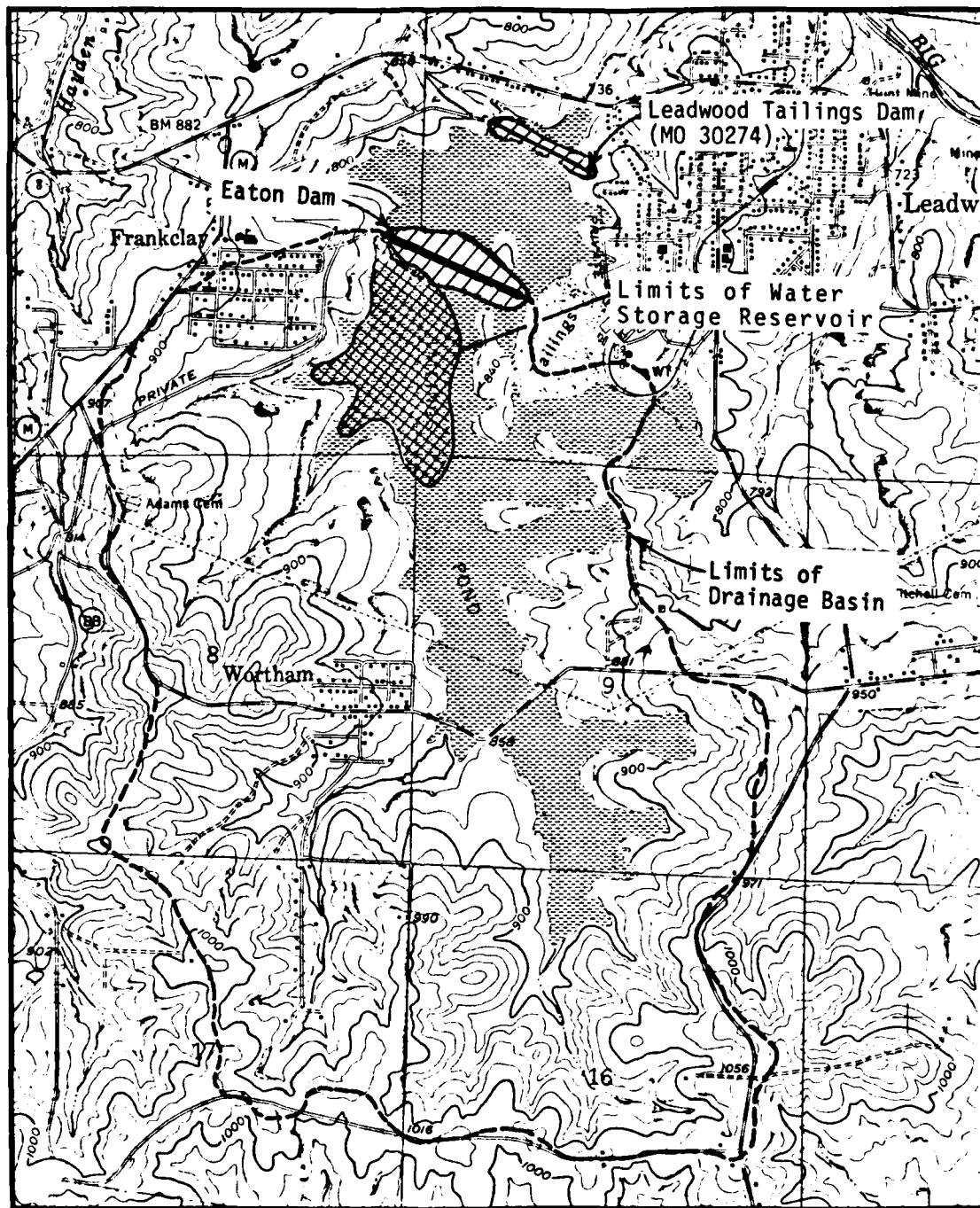
## SITE LOCATION MAP

EATON DAM

MO 31163

Fig. 1





0 2000 4000  
Scale, feet



Notes:

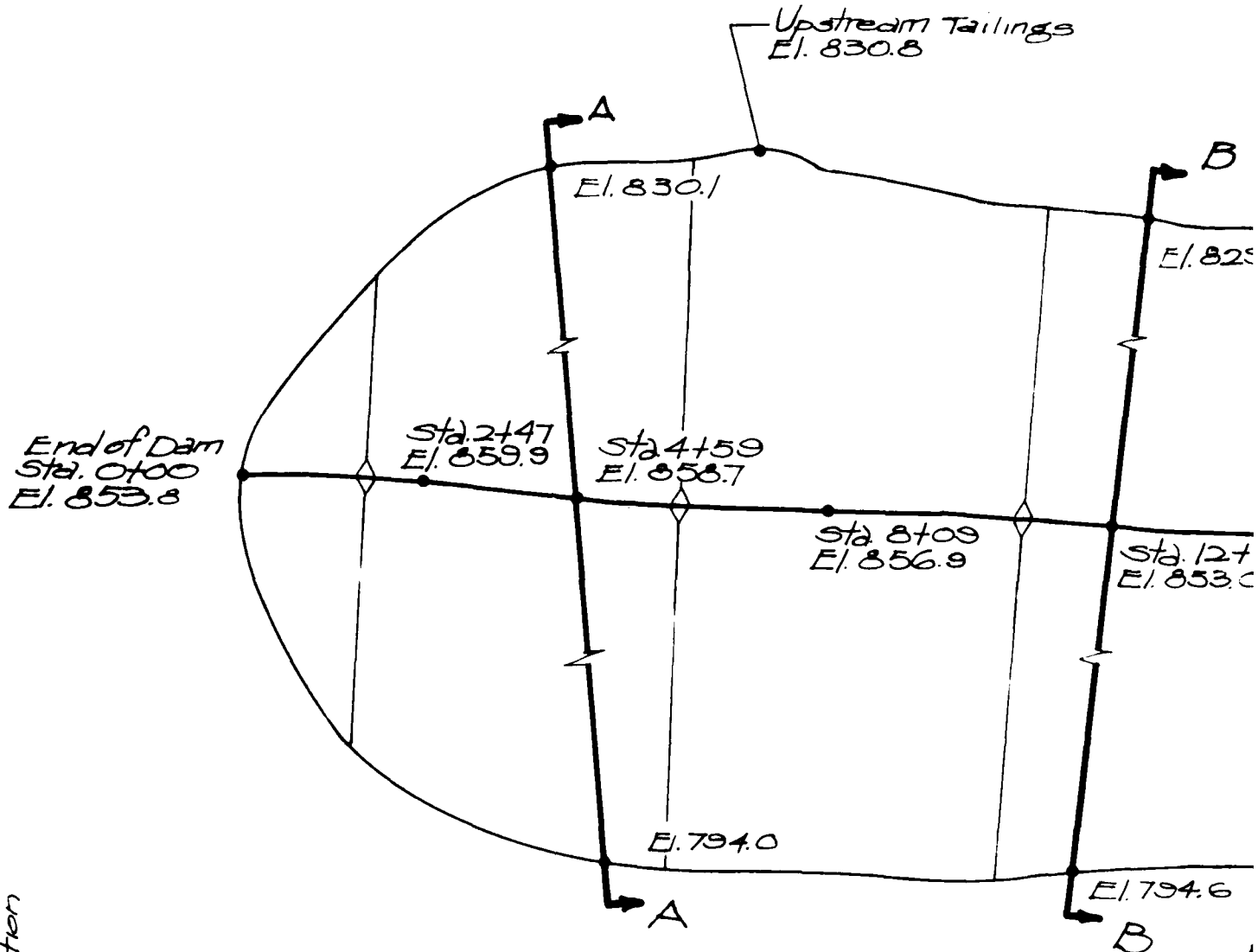
1. Topography from USGS Flat River 7.5-minute quadrangle map (1958).
2. Tailings surface dry at time of inspection.

## DRAINAGE BASIN AND SITE TOPOGRAPHY

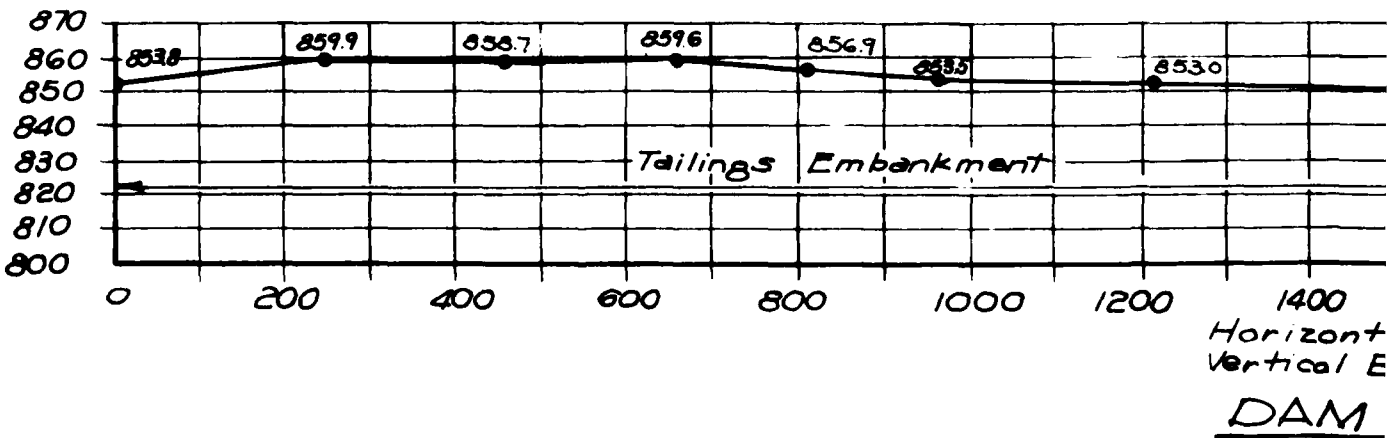
EATON DAM

MO 31163

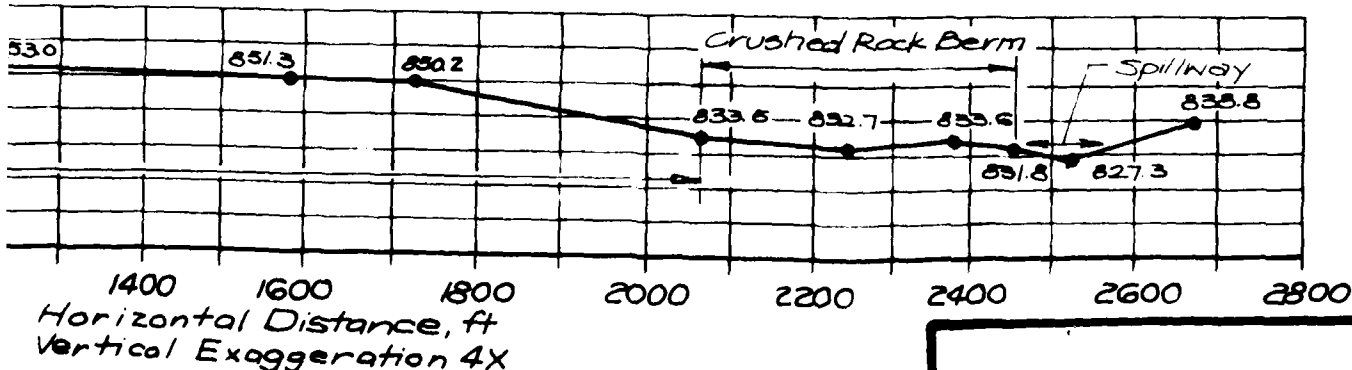
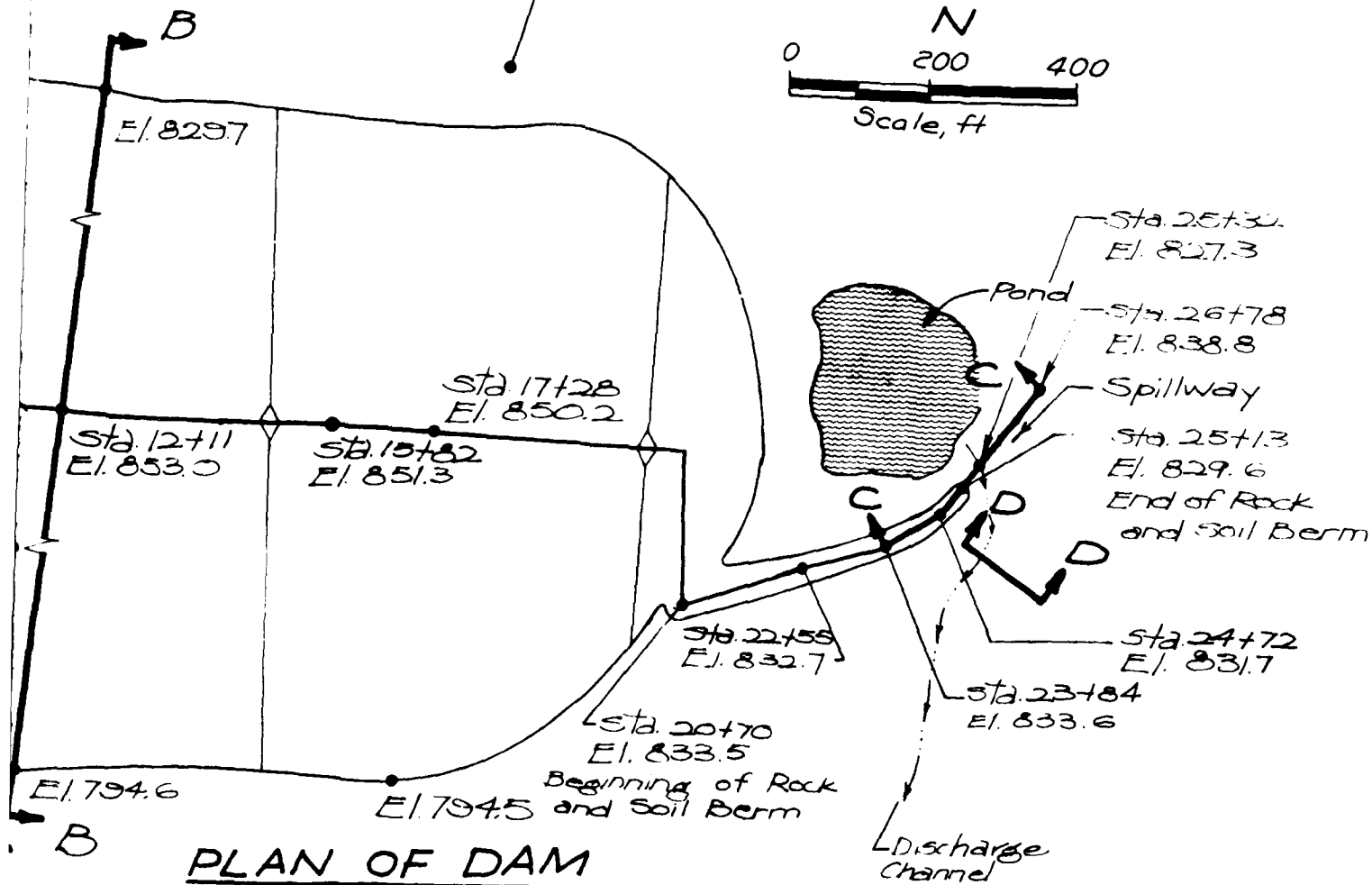
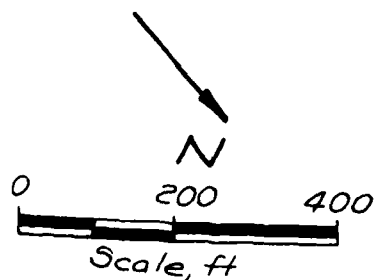
Fig. 2



Elevation, ft. (MSL)  
Vertical Exaggeration  
4 x Horizontal



Upstream Tailings  
El. 828.7



Note:

Surveyed 13 Nov '80  
by James F McCaul and  
Associates, Consulting  
Engineers/Land Surveyors  
Potosi, Missouri

## PLAN AND PROFILE OF DAM

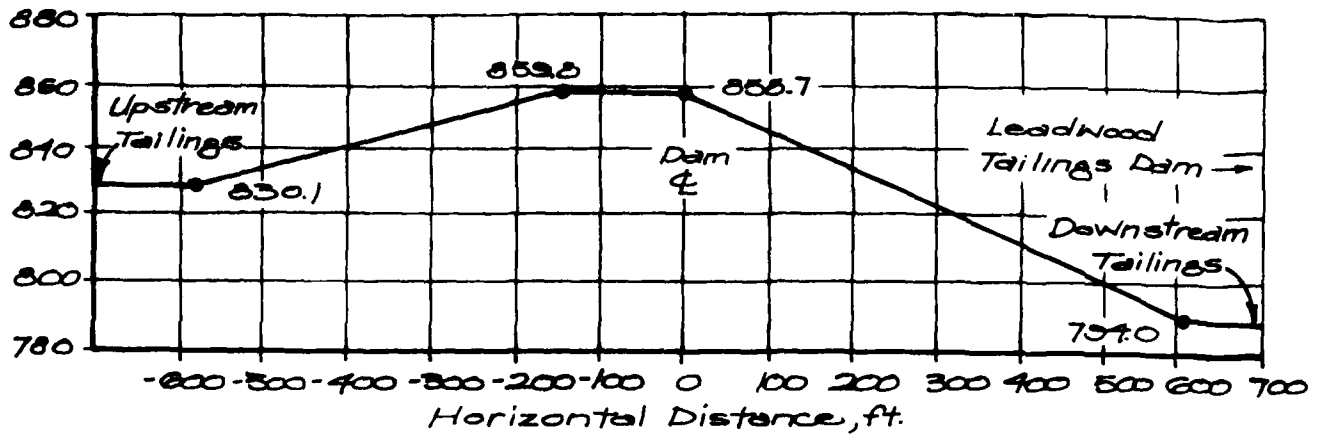
EATON DAM

MO 31163

Fig. 3-A

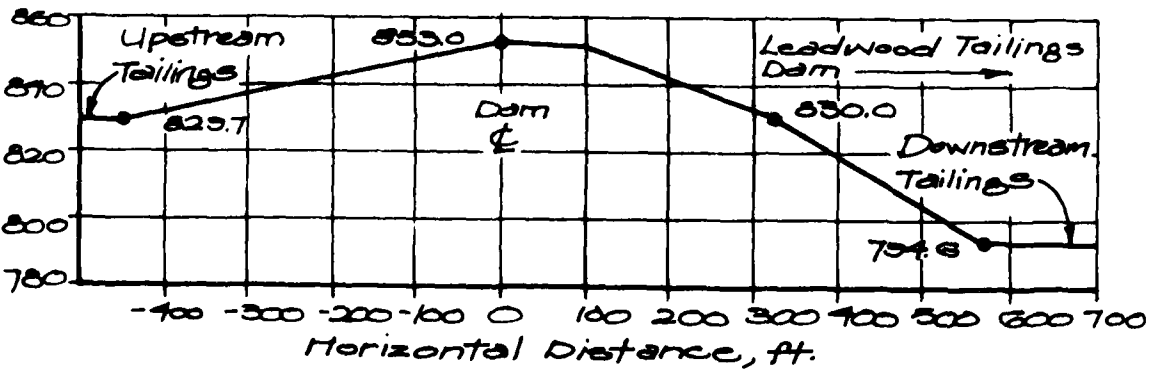
2

Elevation, ft. (MSL)  
Vertical Exaggeration  
4 X Horizontal



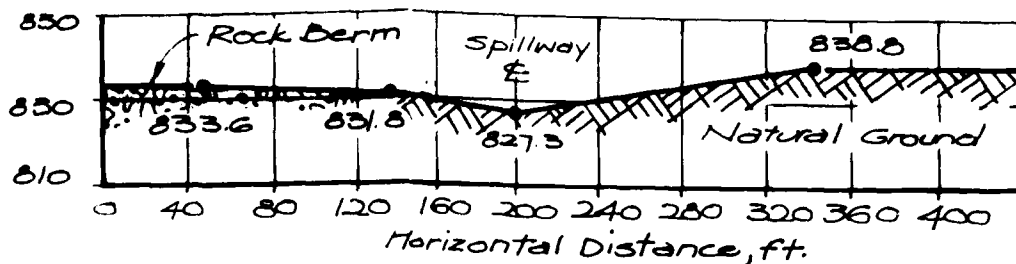
SECTION A-A  
Maximum Dam Section

Elevation, ft. (MSL)  
Vertical Exaggeration  
4 X Horizontal



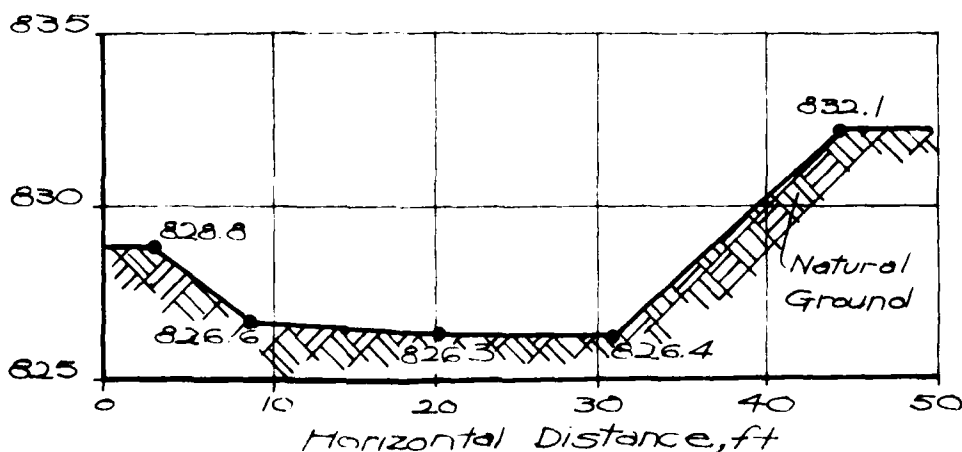
SECTION B-B  
Dam Section

Elevation ft. (MSL)  
Vertical Exaggeration  
2 X Horizontal



SECTION C-C  
Spillway Section

Elevation ft. (MSL)  
Vertical Exaggeration  
2 X Horizontal



SECTION D-D  
Discharge Channel

Note:  
Surveyed 13 Nov 80 by  
James McCaul and  
Associates, Consulting  
Engineers/Land Surveyors,  
Potosi, Missouri

# DAM, SPILLWAY, AND DISCHARGE CHANNEL CROSS SECTIONS

EATON DAM

MO 31163

Fig. 3-B

2

# Dam Location



## Legend

Or

Roubidoux Formation

Gasconade Dolomite  
Gunter Sandstone Member

Cep

Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Ceb

Bonneterre Formation  
Whetstone Creek Member  
Sullivan Siltstone Member

Reagan Sandstone  
(subsurface, western Missouri)

Lamotte Sandstone

Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup



Scale, mile

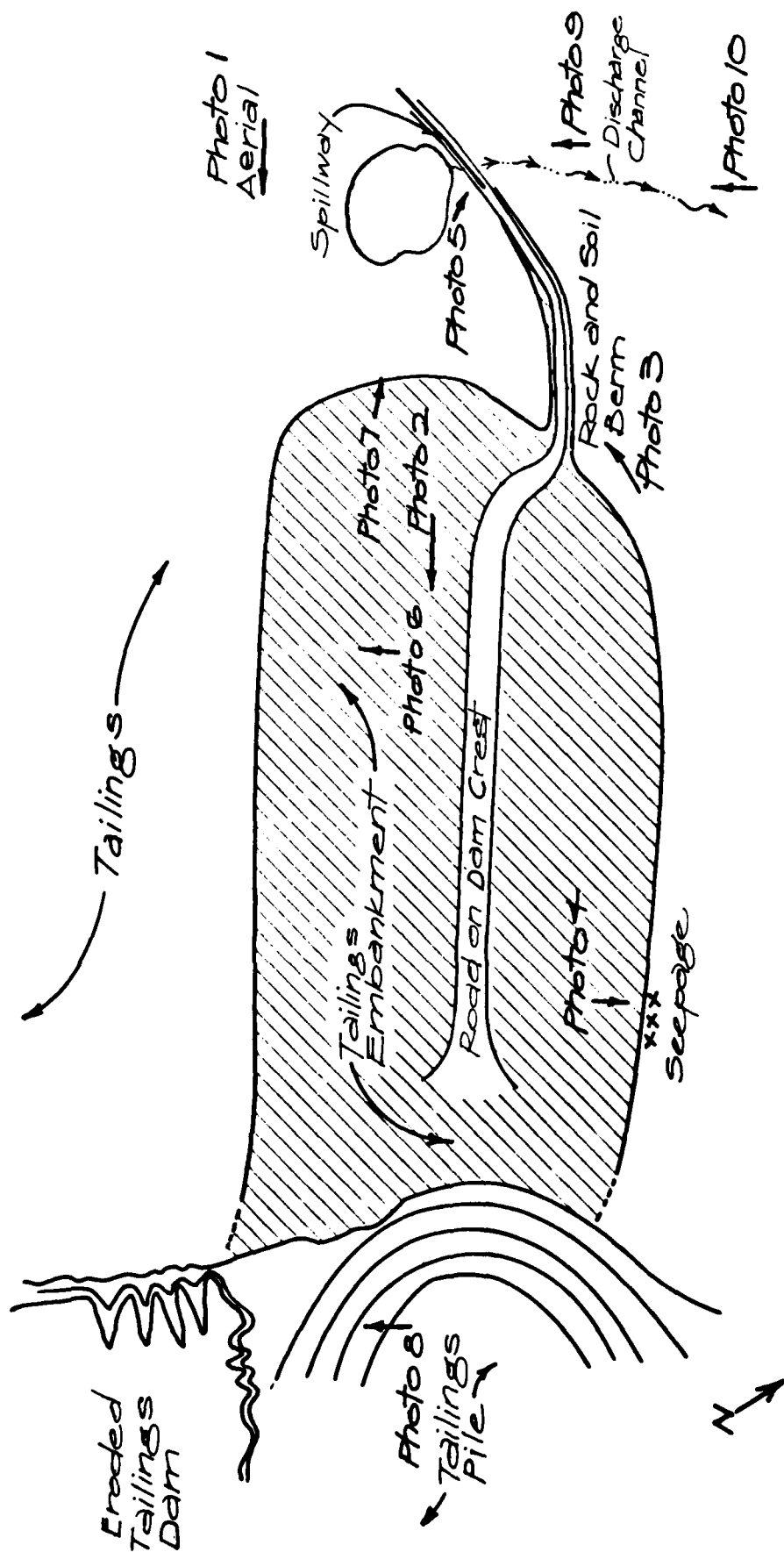
## REGIONAL GEOLOGIC MAP

EATON DAM

MO 31163

Fig. 4

**APPENDIX A**  
**Photographs**



# PHOTO LOCATION SKETCH

EATON DAM

MO 31163

Fig. A-1





1. View along centerline of Eaton Dam, looking east. Note very flat cross sectional profile, tailings pile at far (east) end of dam, and eroded tailings dam and pond to the right of the tailings pile. Also note rock berm and small pool at near (west) end of dam. Spillway is at near end of rock berm.



2. Crest of dam planted with grass for erosion control. Tailings pile in distance at east end of dam. Looking east along crest.



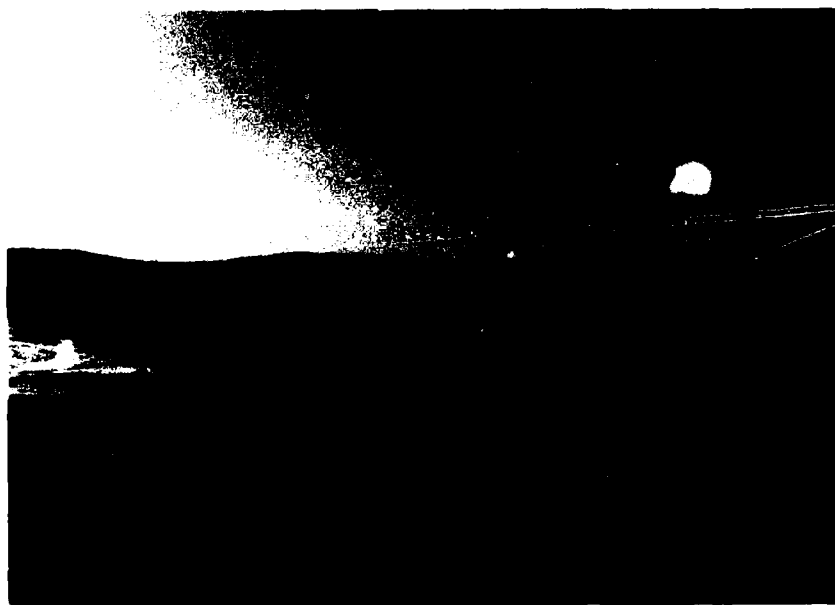
3. Rock berm at west end of dam. Road along crest of berm. Impoundment is on the other side of berm. Looking southwest.



4. Seepage area at toe of Eaton Dam. Leadwood Tailings Dam and reservoir in the distance. Seepage estimated at approximately 5 gpm. Looking north.



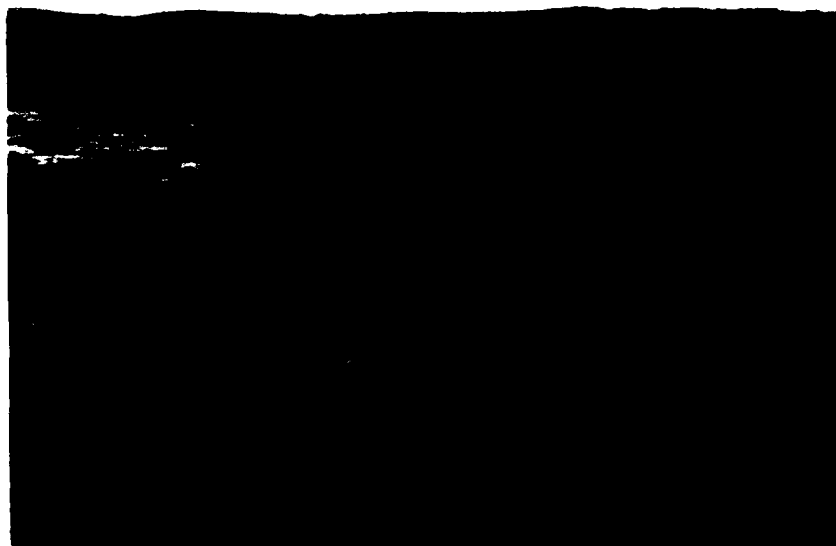
5. Spillway notch at west end of dam. Unpaved road crosses spillway in foreground. Looking north (downstream). Note bedrock exposed on far side of road in floor of spillway and downstream channel.



6. View of tailings area from crest of dam. Note lack of standing water and generally unvegetated tailings surface. Looking south (upstream) from crest of dam.



7. Small pond of standing water at upstream end of spillway. Spillway is at extreme right side of photo. Looking west.



8. Remnants of eroded tailings dam and pond. Gray unbedded material at right is former dam; light gray bedded material to the left is impounded tailings. View from top of tailings pile shown in Photos 1 and 2. Looking south.



9. Discharge channel below spillway. Channel is eroded to bedrock. Spillway is in the distance. Looking south, (upstream).



10. Waterfall eroded in spillway discharge channel. Note some solutioning has occurred along joints. Also note interbedded dolomite (top of falls) and shale (base of falls). Looking south (upstream).

## **APPENDIX B**

### **Hydraulic/Hydrologic Data and Analyses**

## APPENDIX B

### Hydraulic/Hydrologic Data and Analyses

#### B.1 Procedures

- a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.
- b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956, reprinted 1967).
- c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (SCS, 1971, Hydrology: National Engineering Handbook, Section 4) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi<sup>2</sup>, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8} (s+1)^{0.7}}{1900 Y^{0.5}} \quad (\text{Equation 15-4})$$

where:  $L$  = lag in hours  
 $\ell$  = hydraulic length of the watershed in feet = 9000  
 $s = \frac{1000}{CN} - 10 = 3.333$

$CN$  = hydrologic soil curve number as indicated in Section B.2e.  
 $Y$  = average watershed land slope in percent = 2.6.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad (\text{Equation 15-3})$$

where:  $T_c$  = time of concentration in hours  
 $L$  = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \quad (\text{Equation 16-12})$$

where:  $\Delta D$  = duration of unit excess rainfall  
 $T_c$  = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 15 minutes was used.

- d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

- e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:
- (1) 1 and 10 percent probability events - 827.3 ft, spillway crest elevation
  - (2) Probable Maximum Storm - 827.3 ft, spillway crest elevation
- f. Spillway Rating Curve. The relatively flat slope of the discharge channel downstream from the spillway suggests discharge is not free outflow from the spillway, but is controlled by the discharge channel configuration. Therefore, the HEC-2 computer program was used to compute the spillway rating curve using discharge channel cross sections and conveyance characteristics.

## B.2 Pertinent Data

- a. Drainage area. 2.70 mi<sup>2</sup>
- b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 15 minute intervals in order to develop the inflow hydrograph.



- c. Lag time. 1.34 hr.
- d. Hydrologic soil group. C
- e. SCS curve numbers.
  - 1. For PMF- AMC III - Curve Number 88
  - 2. For 1 and 10 percent probability-of-occurrence events - AMC II - Curve Number 75
- f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Flat River 7.5 minute quadrangle map (1958). The tailings surface of the reservoir slopes toward the dam. As a result the entire area is not available for water storage. The tailings surface contours were interpreted from contours extended to the tailings surface from the adjacent hillsides. The data were entered on the \$A and \$E cards so that the HEC-1 program could compute storage volumes. Tailings storage was calculated by planimetering areas on a pre-dam topographic map, dated 1905.
- g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the \$D, \$L, and \$V cards.
- h. Outflow capacity. The spillway rating curve was developed from the cross section data of the spillway and the downstream channel, using the HEC-2 backwater program. This analysis indicated the discharge capacity is apparently controlled by the discharge channel rather than the spillway configuration. The results of the HEC-2 analysis were entered on the Y4 and Y5 cards of the HEC-1 program.
- i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 827.3 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 827.3 ft, the spillway crest elevation.

### B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

ERTON FIRE OAK, NO. 31153, ST. FRANCIS COUNTY, MISSOURI.  
WJOD-ARD-CLYDE CONSULTANTS. HOUSTON JOB 80C224.  
PROBABLE MAXIMUM FLOODS.

Input Data  
Various PMF Events  
Eaton Dam  
MO 31163  
B4

BAW 38874 JULY 1978  
LAST MODIFICATION 01 APR 80  
\*\*\*\*\*

4UM DATE: 27 JAN 81  
TIME: 15.32.43

EATON MINE DRY NO. 3105 ST. FRANCIS COUNTY, MISSOURI.  
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.  
PROBABLE MAXIMUM FLOODS.

JOB SPECIFICATION									
NO	MNR	MMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRY	MSTAM
192	0	15	0	0	0	0	0	0	0
JOPER 5 NMT LROPT TRACE									
-0 -0 -0									

MULTI-PLAN ANALYSES TO BE PERFORMED

MPPLAN= 1-NRTO= 2-LRTO= 1

RTIOS= .50 1.00

\*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

EATON MINE INFLOW COMPUTATIONS: PMF.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRY	IMAME	ISTAGE	TAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

INWUG	IUN6	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNDW	ISAME	LOCAL
1	2	2.70	-0.	2.70	1.00	-0.	-0	-0	-0

PRECIP DATA

SPFE	PHS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LEOPI	STKR	OLTR	RTIOL	EKAIN	STRS	RTIOM	STREL	CMSTL	ALSHX	QVIMP
0.	0.	0.	1.00	0.	0.	1.00	1.00	0.00	0.	0.

CURVE NO = -88.00 4EINSS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA

TC= -0. LAG= 1.34

RECESSION DATA

STRTJ= -1.00 ORCSN= -.05 RTIOM= 9.00

UNIT HYDROGRAPH 24 END OF PERIOD ORIGINATES: TC= -0. HOURS: LAG= 1.34 VOL= 1.00  
71. 213. 430. 706. 857. 889. 831. 720. 406.  
19. 15. 11. 9. 7. 5. 3. 2. 0.

END-OF-PERIOD FLOW													
MO.DA	HR.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.12	1	.00	.00	.00	2.	1.02	.15	97	.04	.04	.01	33.
1.01	.30	2	.00	.00	.00	2.	1.02	.30	98	.04	.04	.01	40.

Output Summary  
Various PMF Events  
Eaton Dam  
MO 31163  
B5

END-OF-PERIOD FLOW															
0	MD.DA	HN.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q	MD.DA	HN.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q	
	1.01	1.15	1	.00	.00	.00	2.	1.02	.15	97	.04	.04	.01	33.	
	1.01	1.30	2	.00	.00	.00	2.	1.02	.30	98	.04	.04	.01	40.	
	1.01	1.45	3	.00	.00	.00	2.	1.02	.45	99	.04	.04	.01	45.	
	1.01	1.00	4	.00	.00	.00	2.	1.02	1.00	100	.04	.04	.00	140.	
	1.01	1.15	5	.00	.00	.00	2.	1.02	1.15	101	.04	.04	.00	108.	
	1.01	1.30	6	.00	.00	.00	2.	1.02	1.30	102	.04	.04	.00	138.	
	1.01	1.45	7	.00	.00	.00	2.	1.02	1.45	103	.04	.04	.00	140.	
	1.01	2.00	8	.00	.00	.00	2.	1.02	2.00	104	.04	.04	.00	191.	
	1.01	2.15	9	.00	.00	.00	2.	1.02	2.15	105	.04	.04	.00	211.	
	1.01	2.30	10	.00	.00	.00	2.	1.02	2.30	106	.04	.04	.00	227.	
	1.01	2.45	11	.00	.00	.00	2.	1.02	2.45	107	.04	.04	.00	236.	
	1.01	3.00	12	.00	.00	.00	2.	1.02	3.00	108	.04	.04	.00	244.	
	1.01	3.15	13	.00	.00	.00	2.	1.02	3.15	109	.04	.04	.00	251.	
	1.01	3.30	14	.00	.00	.00	2.	1.02	3.30	110	.04	.04	.00	256.	
	1.01	3.45	15	.00	.00	.00	2.	1.02	3.45	111	.04	.04	.00	260.	
	1.01	4.00	16	.00	.00	.00	2.	1.02	4.00	112	.04	.04	.00	264.	
	1.01	4.15	17	.00	.00	.00	2.	1.02	4.15	113	.04	.04	.00	266.	
	1.01	4.30	18	.00	.00	.00	2.	1.02	4.30	114	.04	.04	.00	268.	
	1.01	4.45	19	.00	.00	.00	2.	1.02	4.45	115	.04	.04	.00	270.	
	1.01	5.00	20	.00	.00	.00	2.	1.02	5.00	116	.04	.04	.00	271.	
	1.01	5.15	21	.00	.00	.00	2.	1.02	5.15	117	.04	.04	.00	273.	
	1.01	5.30	22	.00	.00	.00	2.	1.02	5.30	118	.04	.04	.00	274.	
	1.01	5.45	23	.00	.00	.00	2.	1.02	5.45	119	.04	.04	.00	275.	
	1.01	6.00	24	.00	.00	.00	2.	1.02	6.00	120	.04	.04	.00	279.	
	1.01	6.15	25	.02	.00	.01	2.	1.02	6.15	121	.20	.19	.01	286.	
	1.01	6.30	26	.02	.00	.01	3.	1.02	6.30	122	.20	.18	.01	317.	
	1.01	6.45	27	.02	.00	.01	3.	1.02	6.45	123	.20	.18	.01	380.	
	1.01	7.00	28	.02	.00	.01	4.	1.02	7.00	124	.20	.18	.01	480.	
	1.01	7.15	29	.02	.00	.01	5.	1.02	7.15	125	.20	.18	.01	603.	
	1.01	7.30	30	.02	.00	.01	6.	1.02	7.30	126	.20	.19	.01	730.	
	1.01	7.45	31	.02	.00	.01	7.	1.02	7.45	127	.20	.19	.01	891.	
	1.01	8.00	32	.02	.00	.01	8.	1.02	8.00	128	.20	.19	.01	956.	
	1.01	8.15	33	.02	.00	.01	9.	1.02	8.15	129	.20	.19	.01	1040.	
	1.01	8.30	34	.02	.00	.01	9.	1.02	8.30	130	.20	.19	.01	1101.	
	1.01	8.45	35	.02	.00	.01	9.	1.02	8.45	131	.20	.19	.01	1148.	
	1.01	9.00	36	.02	.00	.01	10.	1.02	9.00	132	.20	.19	.01	1189.	
	1.01	9.15	37	.02	.00	.01	10.	1.02	9.15	133	.20	.19	.01	1219.	
	1.01	9.30	38	.02	.00	.01	10.	1.02	9.30	134	.20	.19	.01	1237.	
	1.01	9.45	39	.02	.00	.01	10.	1.02	9.45	135	.20	.19	.01	1255.	
	1.01	10.00	40	.02	.00	.01	10.	1.02	10.00	136	.20	.19	.01	1269.	
	1.01	10.15	41	.02	.00	.01	11.	1.02	10.15	137	.20	.19	.01	1281.	
	1.01	10.30	42	.02	.00	.01	11.	1.02	10.30	138	.20	.19	.00	1290.	
	1.01	10.45	43	.02	.00	.01	12.	1.02	10.45	139	.20	.19	.00	1307.	
	1.01	11.00	44	.02	.00	.01	13.	1.02	11.00	140	.20	.19	.00	1303.	
	1.01	11.15	45	.02	.00	.01	13.	1.02	11.15	141	.20	.19	.00	1312.	
	1.01	11.30	46	.02	.00	.01	16.	1.02	11.30	142	.20	.19	.00	1317.	
	1.01	11.45	47	.02	.00	.01	17.	1.02	11.45	143	.20	.19	.00	1316.	
	1.01	12.00	49	.02	.00	.01	19.	1.02	12.00	144	.20	.19	.00	1319.	
	1.01	12.15	49	.02	.02	.04	21.	1.02	12.15	145	.00	.00	.01	1399.	
	1.01	12.30	50	.05	.02	.03	25.	1.02	12.30	146	.66	.65	.01	1459.	
	1.01	12.45	51	.05	.02	.03	32.	1.02	12.45	147	.66	.65	.01	1659.	
	1.01	13.00	52	.05	.02	.03	43.	1.02	13.00	148	.66	.65	.01	1407.	
	1.01	13.15	53	.66	.03	.03	58.	1.02	13.15	149	.80	.79	.01	2393.	
	1.01	13.30	54	.06	.03	.03	74.	1.02	13.30	150	.80	.79	.01	2833.	
	1.01	13.45	55	.06	.03	.03	93.	1.02	13.45	151	.80	.79	.01	3279.	
	1.01	14.00	56	.06	.03	.03	113.	1.02	14.00	152	.80	.79	.01	3706.	
	1.01	14.15	57	.08	.05	.03	134.	1.02	14.15	153	.99	.99	.01	4099.	
	1.01	14.30	58	.08	.05	.03	156.	1.02	14.30	154	.99	.99	.01	4402.	
	1.01	14.45	59	.08	.05	.03	176.	1.02	14.45	155	.99	.99	.01	4792.	
	1.01	15.00	60	.08	.05	.03	203.	1.02	15.00	156	.99	.99	.00	5139.	
								1.02		157	.99	.99	.00	5472.	

Output Summary  
Various PMF Events  
Eaton Dam  
MO 31163  
B7

1.01 14.30	58	.08	.05	.03	135.	1.02 14.30	135	.99	.99	.01	4490.
1.01 14.45	59	.08	.05	.03	178.	1.02 14.45	155	.99	.99	.01	4792.
1.01 15.00	60	.08	.05	.03	203.	1.02 15.00	156	.99	.99	.00	5139.
1.01 15.15	61	.08	.05	.02	228.	1.02 15.15	157	1.01	1.00	.00	5477.
1.01 15.30	62	.16	.11	.04	256.	1.02 15.30	158	2.02	2.01	.01	5841.
1.01 15.45	63	.43	.34	.10	307.	1.02 15.45	159	5.64	5.63	.02	6574.
1.01 16.00	64	.11	.09	.02	383.	1.02 16.00	160	1.41	1.41	.00	7711.
1.01 16.15	65	.07	.06	.01	495.	1.02 16.15	161	.93	.93	.00	9252.
1.01 16.30	66	.07	.06	.01	543.	1.02 16.30	162	.93	.93	.00	10845.
1.01 16.45	67	.07	.06	.01	660.	1.02 16.45	163	.93	.93	.00	11745.
1.01 17.00	68	.07	.06	.01	684.	1.02 17.00	164	.93	.93	.00	11925.
1.01 17.15	69	.06	.05	.01	673.	1.02 17.15	165	.73	.73	.00	11546.
1.01 17.30	70	.06	.05	.01	634.	1.02 17.30	166	.73	.73	.00	10189.
1.01 17.45	71	.06	.05	.01	587.	1.02 17.45	167	.73	.73	.00	9740.
1.01 18.00	72	.06	.05	.01	524.	1.02 18.00	168	.73	.73	.00	8682.
1.01 18.15	73	.01	.00	.00	464.	1.02 18.15	169	.07	.06	.00	7645.
1.01 18.30	74	.01	.00	.00	442.	1.02 18.30	170	.07	.06	.00	7086.
1.01 18.45	75	.01	.00	.00	396.	1.02 18.45	171	.07	.06	.00	6285.
1.01 19.00	76	.01	.00	.00	342.	1.02 19.00	172	.07	.06	.00	5406.
1.01 19.15	77	.01	.00	.00	289.	1.02 19.15	173	.07	.06	.00	4521.
1.01 19.30	78	.01	.00	.00	237.	1.02 19.30	174	.07	.06	.00	3701.
1.01 19.45	79	.01	.00	.00	191.	1.02 19.45	175	.07	.06	.00	2975.
1.01 20.00	80	.01	.00	.00	152.	1.02 20.00	176	.07	.06	.00	2359.
1.01 20.15	81	.01	.03	.00	121.	1.02 20.15	177	.07	.06	.00	1880.
1.01 20.30	82	.01	.00	.00	93.	1.02 20.30	178	.07	.06	.00	1534.
1.01 20.45	83	.01	.00	.00	70.	1.02 20.45	179	.07	.06	.00	1272.
1.01 21.00	84	.01	.00	.00	69.	1.02 21.00	180	.07	.06	.00	1073.
1.01 21.15	85	.01	.00	.00	60.	1.02 21.15	181	.07	.06	.00	928.
1.01 21.30	86	.01	.00	.00	53.	1.02 21.30	182	.07	.06	.00	808.
1.01 21.45	87	.01	.00	.00	48.	1.02 21.45	183	.07	.06	.00	721.
1.01 22.00	88	.01	.00	.00	43.	1.02 22.00	184	.07	.06	.00	653.
1.01 22.15	89	.01	.00	.00	40.	1.02 22.15	185	.07	.06	.00	600.
1.01 22.30	90	.01	.00	.00	37.	1.02 22.30	186	.07	.06	.00	558.
1.01 22.45	91	.01	.00	.00	35.	1.02 22.45	187	.07	.06	.00	523.
1.01 23.00	92	.01	.00	.00	34.	1.02 23.00	188	.07	.06	.00	504.
1.01 23.15	93	.01	.00	.00	33.	1.02 23.15	189	.07	.06	.00	489.
1.01 23.30	94	.01	.00	.00	32.	1.02 23.30	190	.07	.06	.00	479.
1.01 23.45	95	.01	.00	.00	32.	1.02 23.45	191	.07	.06	.00	470.
1.02 0.	96	.01	.00	.00	11.	1.03 0.	192	.07	.06	.00	464.
SUM 36.40 34.07 1.43 240633.							( 925.11 888.11 36.11 6613.971				

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE FEET (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION STATION AREA PLAN RATIO 1 RATIO 2  
 .50 1.00

HYDROGRAPH AT INFLJN 2.70 1 5965. 11029.  
 6.991 168.7011 337.3011

ROUTED TO DAM 2.70 1 4616. 10725.  
 6.991 130.7011 303.6711

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE SPILLWAY CREST TOP OF DAM  
 ELEVATION 827.30 827.30 831.80  
 STORAGE 0. 0. 434.  
 OUTFLOW 0. 0. 1022.

RATIO OF PMF .50 1.00  
 MAXIMUM RESERVOIR DEPTH 2.54 4.10  
 MAXIMUM STORAGE AC-FT 877. 1207.  
 MAXIMUM OUTFLOW CF. 4616. 10725.  
 DURATION OVER TOP HOURS 7.75 10.75  
 TIME OF MAX OUTFLOW HOURS 41.75 41.50  
 TIME OF FAILURE HOURS 0. 0.

Output Summary  
 Various PMF Events  
 Eaton Dam  
 MO 31163  
 B8

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN RATIO	1 RATIO	2 RATIO	3 RATIO	4 RATIO	5 RATIO	6 RATIO
				.15	.16	.17	.18	.19	.20
RATIOS APPLIED TO FLOWS									
HYDROGRAPH AT INFLUX	2.70	1	1784.	1404.	2028.	2147.	2267.	2386.	
	0.991		30.6711	34.0311	37.4311	40.8011	44.1811	47.5611	
ROUTED TO DAM	2.70	1	793.	858.	922.	985.	1047.	1111.	
	0.991		22.4611	24.2411	26.1111	27.9911	29.8611	31.7311	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM		
	STORAGE	827.30	827.30	831.80		
	OUTFLOW	0.	0.	1022.		
RATIO OF PMF	MAXIMUM RESERVOIR DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.15	0.	352.	793.	0.	43.00	0.
.16	0.	375.	858.	0.	43.00	0.
.17	0.	398.	922.	0.	43.00	0.
.18	0.	421.	985.	0.	43.00	0.
.19	0.	443.	1047.	1.25	43.00	0.
.20	.19	465.	1111.	2.25	43.00	0.

Output Summary  
 Various PMF Events  
 Eaton Dam  
 MO 31163  
 B9





DATE: 27 JAN 81  
TIME: 19.32.43

LEXTON NINE DRG. NO. 3163, ST. FRANCIS COUNTY, MISSOURI.  
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.  
PROBABILISTIC FLOOD - 100 YEAR.

## JOB SPECIFICATION

NO	NHR	NRIN	LDAY	IMR	IMIN	METRC	IPLT	IPRT	MSTAN
1	0	1	0	0	0	0	0	0	0
2	0	1	0	0	0	0	0	0	0
3	0	1	0	0	0	0	0	0	0

## SUB-AREA RUNOFF COMPUTATION

RAIN STA. 10-LESTERVILLE, FREQ= 1.0, INTERVAL= 15. MIN., DURATION= 40 HRS.

ISTAO	ICOMP	IRECON	ITAPE	JPLY	JPRY	IRNAME	ISTAGE	IRUVO
IN+LOW	0	-0	-0	-0	-0	1	-0	-0

## ~~HYDROGRAPH DATA~~

INWDG	TUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	2.70	-0.	2.70	1.00	-0.	-0	-0	-0

**PRECIP DATA**

NP	STORM	DAJ	D
142	5.89	0.0	0.0

Output Summary  
1% Probability of Occurrence Event  
Eaton Dam  
MO 31163  
Bll

### LOSS DATA

EMPT	STKR	ULTR	ATOL	ERIN	STKS	RTOK	STATL	CMSTL	ALSMX	RTYMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-75.00	-0.	.10

CURVE NO = 75.00    WETNESS = -1.00    EFFECT CN = 75.00



Output Summary  
 1% Probability of Occurrence Event  
 Eaton Dam  
 MO 31163  
 B13

1.01	10.30	42	.02	.00	.01	11.	1.02	10.30	138	.04	.03	.01	179.
1.01	10.45	43	.02	.00	.01	11.	1.02	10.45	139	.04	.03	.01	181.
1.01	11.00	44	.02	.00	.01	11.	1.02	11.00	140	.04	.03	.01	183.
1.01	11.15	45	.02	.00	.01	11.	1.02	11.15	141	.04	.03	.01	185.
1.01	11.30	46	.02	.00	.01	11.	1.02	11.30	142	.04	.03	.01	187.
1.01	11.45	47	.02	.00	.01	12.	1.02	11.45	143	.04	.03	.01	189.
1.01	12.00	48	.02	.00	.01	12.	1.02	12.00	144	.04	.03	.01	190.
1.01	12.15	49	.02	.00	.01	12.	1.02	12.15	145	.07	.05	.02	192.
1.01	12.30	50	.02	.00	.01	13.	1.02	12.30	146	.08	.05	.02	194.
1.01	12.45	51	.02	.00	.01	14.	1.02	12.45	147	.08	.05	.02	210.
1.01	13.00	52	.02	.00	.01	14.	1.02	13.00	148	.08	.05	.02	224.
1.01	13.15	53	.02	.00	.01	15.	1.02	13.15	149	.08	.05	.02	251.
1.01	13.30	54	.02	.00	.01	16.	1.02	13.30	150	.08	.05	.02	274.
1.01	13.45	55	.02	.00	.01	17.	1.02	13.45	151	.10	.07	.03	298.
1.01	14.00	56	.02	.00	.01	18.	1.02	14.00	152	.10	.07	.03	322.
1.01	14.15	57	.02	.00	.01	19.	1.02	14.15	153	.18	.13	.04	341.
1.01	14.30	58	.02	.00	.01	19.	1.02	14.30	154	.18	.14	.04	391.
1.01	14.45	59	.02	.00	.01	20.	1.02	14.45	155	.42	.33	.09	458.
1.01	15.00	60	.02	.00	.01	21.	1.02	15.00	156	.76	.63	.14	509.
1.01	15.15	61	.02	.00	.01	22.	1.02	15.15	157	1.67	1.45	.22	871.
1.01	15.30	62	.02	.00	.01	22.	1.02	15.30	158	.43	.38	.04	1313.
1.01	15.45	63	.02	.00	.01	23.	1.02	15.45	159	.18	.16	.02	167.
1.01	16.00	64	.02	.00	.01	24.	1.02	16.00	160	.18	.16	.02	24.
1.01	16.15	65	.02	.00	.01	25.	1.02	16.15	161	.10	.09	.01	27.
1.01	16.30	66	.02	.00	.01	25.	1.02	16.30	162	.10	.09	.01	2605.
1.01	16.45	67	.02	.00	.01	26.	1.02	16.45	163	.09	.07	.01	2653.
1.01	17.00	68	.02	.00	.01	27.	1.02	17.00	164	.08	.07	.01	2361.
1.01	17.15	69	.02	.00	.01	28.	1.02	17.15	165	.08	.07	.01	2014.
1.01	17.30	70	.02	.00	.01	28.	1.02	17.30	166	.08	.07	.01	1655.
1.01	17.45	71	.02	.00	.01	29.	1.02	17.45	167	.08	.07	.01	1382.
1.01	18.00	72	.02	.00	.01	30.	1.02	18.00	168	.08	.07	.01	1179.
1.01	18.15	73	.02	.01	.01	30.	1.02	18.15	169	.02	.02	.00	1005.
1.01	18.30	74	.02	.01	.01	31.	1.02	18.30	170	.02	.02	.00	845.
1.01	18.45	75	.02	.01	.01	32.	1.02	18.45	171	.02	.02	.00	747.
1.01	19.00	76	.02	.01	.01	32.	1.02	19.00	172	.02	.02	.00	639.
1.01	19.15	77	.02	.01	.01	33.	1.02	19.15	173	.02	.02	.00	541.
1.01	19.30	78	.02	.01	.01	34.	1.02	19.30	174	.02	.02	.00	454.
1.01	19.45	79	.02	.01	.01	34.	1.02	19.45	175	.02	.02	.00	381.
1.01	20.00	80	.02	.01	.01	35.	1.02	20.00	176	.02	.02	.00	321.
1.01	20.15	81	.02	.01	.01	36.	1.02	20.15	177	.02	.02	.00	274.
1.01	20.30	82	.02	.01	.01	36.	1.02	20.30	178	.02	.02	.00	240.
1.01	20.45	83	.02	.01	.01	37.	1.02	20.45	179	.02	.02	.00	215.
1.01	21.00	84	.02	.01	.01	38.	1.02	21.00	180	.02	.02	.00	196.
1.01	21.15	85	.02	.01	.01	38.	1.02	21.15	181	.02	.02	.00	181.
1.01	21.30	86	.02	.01	.01	39.	1.02	21.30	182	.02	.02	.00	169.
1.01	21.45	87	.02	.01	.01	39.	1.02	21.45	183	.02	.02	.00	159.
1.01	22.00	88	.02	.01	.01	40.	1.02	22.00	184	.02	.02	.00	151.
1.01	22.15	89	.02	.01	.01	41.	1.02	22.15	185	.02	.02	.00	149.
1.01	22.30	90	.02	.01	.01	41.	1.02	22.30	186	.02	.02	.00	141.
1.01	22.45	91	.02	.01	.01	42.	1.02	22.45	187	.02	.02	.00	139.
1.01	23.00	92	.02	.01	.01	42.	1.02	23.00	188	.02	.02	.00	138.
1.01	23.15	93	.02	.01	.01	43.	1.02	23.15	189	.02	.02	.00	137.
1.01	23.30	94	.02	.01	.01	43.	1.02	23.30	190	.02	.02	.00	136.
1.01	23.45	95	.02	.01	.01	44.	1.02	23.45	191	.02	.02	.00	135.
1.02	0.	96	.02	.01	.01	44.	1.03	0.	192	.02	.02	.00	135.
SUM										8.84	6.11	2.73	41610.
										1225.11	195.11	89.11	1179.981



END

DATE  
FILMED

12-81

DTIC